Quarterly Report – Public Page

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Technical Status

GTI has developed a two-sensor, ultrasonic inspection technique for butt fusion joints. A "model" was developed wherein a modest number of independent parameters are required to assess butt fusion quality. Dependent values are determined by testing against only good joints. No flawed joint sections are used to determine the dependent parameters. The number of joints required to determine the parameters is small. To date, the technique has correctly classified all of the butt fusion joints tested.

There are four important advantages to the technique:

- Discrimination decisions can be made automatically without the operator viewing the waveform. This minimizes operator expertise which was a major downfall of previous ultrasonic testing techniques of ASTM D 1598 and the UltraMc®. It should be a major advantage over phased array ultrasonic equipment requiring a highly trained operator.

- The independent parameters are few in number, which facilitates portability across materials and pipe geometries.

- A small number of good joints are required to determine the dependent parameters.

- The potential exists for a very inexpensive instrument to ultrasonically inspect non-metallic fusion joints.

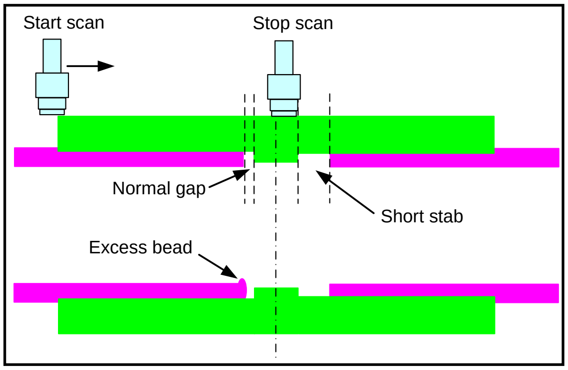
This same approach is being applied to develop the analytical algorithms and sensor scanning patterns for inspecting non-EF socket and saddle fusion joints and for EF fusion joints. The goals for all of the joint inspections are techniques that require minimal ultrasonic expertise by the operator and can be implemented with low cost hardware.

Last quarter, ultrasonic measurements were made on socket tees and socket couplings that had failed in the field. The measurements included detecting the path of a leak through the fusion interface between the socket tee and pipe, poor bonding in a tee with the pipe misaligned at a 5^{o} angle, and a cracked fitting. This quarter, scan patterns were developed for socket tees and couplings. Correctly assessing the quality of heat fusion joints requires complete scanning of the fusion interface in a manner that can observe all of the potential flaws. It is possible to scan by hand, however, that would be a slow, inexact process subject to inspection errors. Thus a second criterion on the scan patterns is their potential to be easily implemented with a mechanical scanner.

The recommended data collection for socket fusion coupling inspection uses a single sensor. The sensor is oriented normally to the coupling or tee and data is collected in a pulse/echo mode. As illustrated in the first figure, the scan pattern should be parallel to axis of pipe, starting with the sensor not completely over the coupling at one edge. The sensor is moved collecting data at each step, until the center of the coupling is reached. The sensor is returned to the front of the coupling. It is shifted one step around the circumference and the next scan is run. In principle, scanning around the circumference could also be used. However, the observed variations in the thickness of the coupling/pipe and the lengths of pipe insertions are great enough to complicate data analysis if circumferential scanning were used. The mechanical scanning device should be designed to scan ½ of coupling. To inspect the second half of the coupling, the mechanism would be removed and placed on the opposite side. The advantage of this approach is the mechanism can also be used to inspect each leg of a socket fusion tee of the same diameter. [Note: Figure 1 illustrates the entire coupling with fusions on both sides, rather than just ½ of the joint.]

Scan patterns and wedge designs for saddle fusion tees were also developed. They present a challenge because of the large number of saddle tee shapes. The geometry of saddle fusion tees varies with manufacturer, diameter of the main the tee is being fused to, and diameter of the outlet pipe. The heights of the bases can vary. In addition, the tops of bases are curved; however, the curvature of the top is not always concentric with the center of the pipe. The latter means the amount of signal returning from a flaw or from the reflection interior of the pipe with a good fusion will vary with sensor position thereby complicating the data analysis. Several sensor/scan geometries were investigated for saddle tees. The geometries included placing the sensors on the body of the pipe, rather than on the saddle tee. We did not find an arrangement where sufficient ultrasonic energy returned to the sensors in either the pulse/echo or pitch/catch modes to allow adequate inspection of the fusion area. GTI concluded that in spite of the drawbacks, for proper inspection, the sensors must be placed on the tee itself.

As shown in the second figure, some saddle tees have a flat, rectangular base that permits easy access for sensors. A combination of two sensor geometries and scan patterns were developed for such saddle tees. It will be difficult to inspect the entire fusion interface of some other saddle tee geometries.



Scan pattern for socket fusion coupling.

This rectangular base permits relatively easy access for inspecting the fusion area.

Work continued to develop a set of data fusion software to inspect all types of butt fusion, non-EF socket and saddle tee fusions, and EF joints for PE pipe. Work this quarter concentrated on data analysis of socket fusion couplings and tees. This project is pursuing the approach of developing ultrasonic inspection techniques that can be implemented in the field with little ultrasonic expertise on the part of the operator and with low-cost hardware. Ideally, the operator does not even have to view a visual display of the data.

For socket fusion couplings and tees, the waveform generated at each discrete sensor location is analyzed to identify irregularities at the fusion interface caused by dirt, lack of fusion, grease, etc., and to identify voids in the coupling or pipe. Additional information is required to assess the quality of the joint: for example, is the length of pipe inserted into the coupling correct? Although the quality of the fusion may be good, if the length of the pipe fused to the coupling is not correct, the joint will be unacceptable.

Results and Conclusions:

Results from the co-funded project are very promising and are being transferred to this PHMSA project. The co-funded project developed a method of analyzing the ultrasonic waveforms from butt fusion joints that requires only a modest number of independent parameters. Dependent parameters are determined from measurements of good joints. This approach has the advantages of requiring minimal operator expertise and being implementable with inexpensive hardware. GTI is successfully applying these techniques to non-EF socket couplings and socket couplings. The sensor scan patterns for these fusion joints are straight forward to implement because of the cylindrical geometry of the fittings.

Plans for Future Activity:

- Complete development of techniques to inspect socket tee and socket couplings
- Continue and complete development of classification algorithms for the EF coupling joints and EF saddle tees
- Complete technical work and write final report.